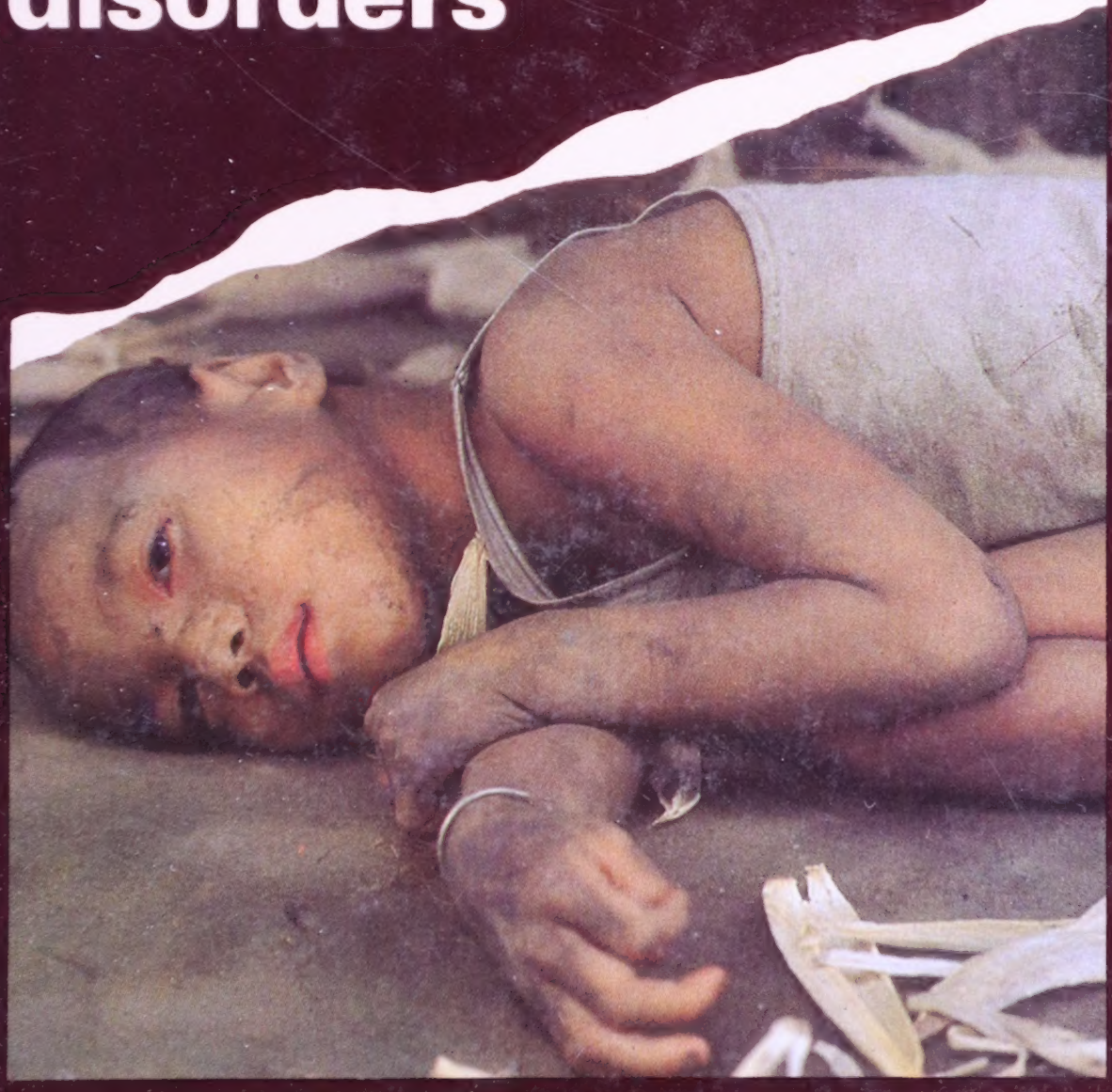
The use of iodated salt in the prevention of iodine deficiency disorders



A HANDBOOK OF MONITORING AND QUALITY CONTROL

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THE USE OF IODATED SALT IN THE PREVENTION OF IODINE DEFICIENCY DISORDERS

A HANDBOOK OF
MONITORING AND
QUALITY CONTROL

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A videotape on the same subject is available from UNICEF/ ROSCA, 73-74 Lodi Estate, New Delhi 110003. Videotapes on Neonatal Hypothyroidism, Monitoring and Evaluation of IDD Control Programmes, and a description of the IDD Control Programme in Bhutan, are also available

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1. Introduction

The investigation of Iodine Deficiency Disorders (IDD) is providing new insights into the extent and consequences of dietary iodine deficiency. Soils lacking iodine do not exist only in mountainous regions, as is generally supposed. These soils are found also in the densely populated plains and river basins which are blighted by periodic floods. In Asia alone, more than 500 million people live in these regions. Consequently, in Asia, over a tenth of the human race is exposed to the risk of IDD.

Goitre is mentioned in ancient writings from China and India; in 2500 BC the Chinese prescribed seaweed to treat goitre. Over forty centuries later, scientists discovered that seaweed is rich in iodine. The function of the thyroid gland and its dependence on iodine intake became known only at the end of the nineteenth century. The gland uses iodine to produce thyroxine, a hormone essential for the growth and development of the body, particularly the cells of the brain.

If a pregnant woman is starved of iodine, the foetus cannot produce enough thyroxine, and foetal growth is retarded. Hypothyroid foetuses often perish in the womb, and many infants die within a week of birth. Hypothyroid children are intellectually subnormal and may also suffer physical impairment. They lack the aptitudes of normal children of similar age, and are often incapable of completing school.

Hypothyroidism is indicated by a low level of thyroxine in the blood. When a baby is delivered, the birth attendant takes special absorbent paper, stains it with blood from the umbilical cord, and posts it to the laboratory for analysis. This technique, developed by the All India Institute of Medical Sciences, New Delhi, makes it possible to determine the incidence of neonatal hypothyoidism (NH) in the remotest communities.

NH screening in the Himalaya and the Indian tarai shows that upto 15 per cent of newborn children are hypothyroid, indicating the prevalence of intellectual subnormality in iodine-deficient populations. These communities tend to remain poor in spite of increased inputs for education and human resource development.

Figure 1 Collecting a cord blood sample to test for hypothyroidism

Figure 2 Cord blood sample received at the laboratory for analysis

This social and economic devastation—and injustice to millions of unsuspecting people—must, and can, be ended forthwith. In 1978, the UNICEF Executive Director said:

"Iodine deficiency is so easy to prevent that it is a crime to let a single child be born mentally handicapped for that reason."

IDD can be prevented by the regular consumption of salt fortified with iodine, or by administering a preparation of iodine-rich oil. The total cost of iodating all salt for human and animal consumption is only about US$ 0.05 per person per year—the price of a cup of tea for every inhabitant! The cost may be higher if iodated salt is marketed only where IDD is endemic, but will rarely exceed US$ 0.25 per beneficiary per year.

Iodized oil can be injected or swallowed, but the recurring cost is higher than that of salt iodation. However, since iodized oil provides a depot of iodine in the body sufficient for a year or longer, it gives time for the technical, administrative and legal arrangements for salt iodation to be made. Iodized oil is highly effective as an interim preventive measure and therefore should be administered to groups severely affected by IDD, and especially to women of child-bearing age.

Iodine deficiency is no longer a relatively insignificant problem of goitre and cretinism. Perceived in the correct perspective of impaired human development and economic progress, it deserves the attention of national leadership. Indeed, iodine deficiency is everybody's concern, and it is every individual's duty to make the problem, and the remedy, more widely known.

What UNICEF's Executive Director said in 1978 is now more meaningful than ever, for iodine deficiency has since caused unimaginable suffering and incalculable losses. The urgency for eradicating IDD is now stated again, and the weapon—so simple, so affordable, and so effective—is at hand.

The responsibility of initiating programmes to eradicate IDD rests primarily with the government, but the process must be speeded and the momentum sustained. Trade associations, co-operatives, consumer organizations, voluntary agencies, colleges, schools and other institutions, as well as individuals, can help ensure the success of salt iodation programmes. Each one has a role to play in eradicating IDD in the world.

2. Prevention of Iodine Deficiency Disorders

Iodine is an essential nutrient. The normal human requirement is 150 micrograms per day (1,000,000 micrograms = 1 gram). About 90 per cent of this normally comes from food, and the rest from water. Foodcrops and water derive iodine from the soil.

Iodine Deficiency Disorders

Some soils contain more iodine than others. Soils which are poor in iodine content are common in mountainous regions and in the plains and river basins where iodine is periodically washed away by heavy rainfall or floods. Crops grown in these soils are deficient in iodine. Consequently, Iodine Deficiency Disorders (IDD) appear. The relationship between iodine intake and IDD is shown in Table 1.

Table 1

RELATIONSHIP BETWEEN IODINE INTAKE AND IDD

Nutritional Status	Daily iodine intake (micrograms)
Associated with cretinism	20 or less
Associated with goitre	20 - 50
Marginal	50 - 100
Normal	**100 - 300**
High	300 - 500
Possibly excessive	500 - 1000

Source: Stanbury & Hetzel: "Endemic Goitre and Endemic Cretinism", John Wiley & Sons, Inc. 1980.

Goitre, an enlargement of the thyroid gland, is an obvious disorder caused by iodine deficiency. Other disorders include mental retardation and physical disabilities such as stunted growth, defects of stance and gait, squint, lack of muscular

Figure 3 Periodically flooded land is often deficient in iodine

co-ordination, and deaf-mutism. Cretinism is a condition of mental retardation combined with some of the other infirmities. Iodine starvation in pregnancy leads to foetal hypothyroidism which retards the development of the unborn child and increases the incidence of abortions, still births, perinatal mortality, and mental subnormality.

Figure 4 shows regions of the world where goitre has been endemic. However, as research continues, more and more areas are being found to be iodine-deficient. According to recent estimates, about 500 million Asians inhabit such areas. It is estimated that in Asia alone, 175 million people, including 35 million children, are afflicted by IDD (Table 2).

Table 2

EXTENT OF IDD IN ASIA

Country	Estimated population at risk (in millions)	Estimated goitrous population (in millions)	Estimated population with IDD (0-15 yrs) (in millions)
Afghanistan	1.0	0.4	0.08
Bangladesh	23.0	18.2	1.84
Bhutan	1.3	0.8	0.10
Burma	4.0	1.6	0.32
China	280.0	78.0	16.00
India	120.0	40.0	9.60
Indonesia	23.0	9.0	1.84
Kampuchea	1.8	0.7	0.14
Laos	1.1	0.4	0.09
Malaysia	1.2	0.4	0.10
Nepal	14.0	8.3	1.10
Pakistan	2.7	1.1	0.22
Philippines	15.3	6.0	1.20
Sri Lanka	8.5	3.3	0.68
Thailand	2.0	0.8	0.16
Vietnam	17.0	6.6	1.36
Total	515.9	175.6	34.83

Source: "Regional Support Through Country Programmes of Cooperation for the Control of IDD in Asian Countries": UNICEF/ROSCA 1983.

Figure 4

The problem

IDD appears in many forms, some of which are illustrated below.

Figure 5 Goitre

Figure 6 A hypothyroid child; note the vacant look

Figure 7 Stunted growth; note the unnaturally short legs

Figure 8 A deaf-mute with squint and goitre

Figure 9 A 10-year old cretin

Figure 10 A 12-year old cretin

Iodation of salt

IDD is preventable by supplementing the diet regularly with iodine. An inexpensive and effective preventive method is to add iodine to salt. IDD has been controlled in many industrialized countries and to some extent, in a few developing countries in South America and Asia, by making iodated salt widely available at a competitive price.

The iodation of salt is a simple process which can be carried out by salt manufacturers and small-scale entrepreneurs. Different methods may be used, depending on the amount of salt to be processed. Continuous spray mixing is the most economical method for large quantities of iodated salt. The salt is sprayed with a compound of iodine, usually potassium iodate. It is mixed in a screw conveyor and bagged.

Increasing the concentration of iodine has no adverse effect on the consumer, but salt with too little iodine cannot prevent IDD. The manufacturer controls the level of iodation by adjusting the spray and the amount of salt travelling under it. He must frequently test the iodine content to ensure adequate iodation, for which a trained technician and a small laboratory are required at each plant. The capital cost of a 5-ton-per-hour spray mixing plant and quality-control laboratory is approximately US$ 35,000. The operating cost is about US$ 7 per metric ton of salt, including the cost of potassium iodate ($ 1.50) and high-quality packaging ($ 4).

Iodine concentration is specified as the number of parts of iodine per million parts of salt, or "ppm". Salt should contain at least 15 ppm iodine to provide the normal requirement of 150 micrograms per day to the consumer. It is usually necessary to iodate the salt at higher levels—50 ppm or more—to compensate for the loss of iodine in storage and distribution.

Iodine retention of salt

The iodine level in iodated salt diminishes constantly due to the chemical instability of iodine compounds. The loss becomes great when the salt is exposed to moisture, sunlight or heat, and when the salt is contaminated by organic matter. If there is excessive moisture, water is absorbed by the salt and the iodine migrates downwards and escapes from the bottom of the

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bag. When atmospheric humidity is low, the salt releases surface moisture which may also result in some loss of iodine.

These losses should be minimized to preserve the nutritional value of the salt. Iodated salt should be packed and sealed in moisture-proof bags and must always be carefully shielded from moisture, sunlight and high temperature. Consumers should be advised to use the salt within a year of iodation.

Experience shows that all the iodine can be lost if these precautions are not taken. The causes of iodine loss and the points at which losses are likely to occur are given below:

- At the iodation plants, due to inadequate supervision, poor quality control, or inadequate weather protection of the plant and stocks of iodated salt.
- By the use of ordinary unlined jute bags.
- By storing iodated salt in the open or in damp or poorly ventilated godowns.
- By failure to despatch iodated salt on a "first in, first out" basis, thus needlessly prolonging the period of storage.
- By transporting iodated salt in open trucks or railway wagons.
- By keeping and selling iodated salt outdoors, and/or in the open.
- By storing iodated salt for long periods in the home.
- By the practice of washing salt before use.

Monitoring and control of iodine loss

There are many examples to show that salt which has lost most of its iodine has no impact on IDD. On the other hand, IDD has been eradicated by ensuring an effective level of iodine in the salt. Careful monitoring and control of iodine levels at the production, storage, sale and consumption stages, and prevention of the salt of uniodated or substandard iodated salt, are vital components of salt iodation programmes. The elements of a monitoring system are given on page 13. Such systems should be a part of all salt iodation programmes, with variations introduced to suit local conditions and requirements.

Monitoring: Stage 1
Location: salt iodations plants
Iodine content: not less than 60 ppm.
Frequency of testing: Every hour

Monitoring: Stage 2
Location': Wholesale depots
Iodine content: not less than 40 ppm.
Frequency of testing: once a week

Monitoring: Stage 3
Location: retail outlets
Iodine content: not less than 25 ppm.
Frequency of testing: once a month
Latest date of sale: 9 months after iodation

Monitoring: Stage 4
Location: households
Iodine content: not less than 15 ppm
Frequency of testing: As often as possible
Latest date of consumption: 12 months after iodation

The iodine level in iodated salt is determined by a simple laboratory procedure called *iodometric titration*. Testing *must* be done by all salt manufacturers and iodation plant operators. Food laboratories and trade inspectors must periodically test samples of salt drawn from wholesalers, retail shops, and households. Any salt containing less than the prescribed level should be iodated again, or diverted for industrial use. Testing *should* be done by consumer groups, trade associations, voluntary agencies, hospitals and health centres. It *can* also be done by students in school and college laboratories. The following chapters explain the principle of iodine testing and describe each step of the procedure so that non-technical persons can also carry it out successfully and accurately.

Advocacy and communication

There is a general lack of awareness of the extent and severity of IDD is Asia. This situation must be corrected by systematically

implementing campaigns to advocate, inform, educate and communicate.

Vigorous advocacy for IDD control will gain political support and accelerate decision-making and the formulation of policy. It will also strengthen links between the ministries and agencies involved in salt iodation programmes.

IDD should be included in the training of health professionals and medical doctors. Salt manufacturers and others involved in implementing salt iodation programmes should be informed of the IDD problem. Their training should emphasise the monitoring and quality control aspects of salt iodation.

Public consciousness must be raised particularly in communities affected by iodine deficiency disorders.

Preventing the problem

IDD can be prevented and controlled by programmes of iodine supplementation. Iodized oil, given orally or injected, provides a depot of iodine for one to five years of prevention, and gives sufficient time to introduce iodated salt for the long-term control of IDD.

Figure 11 Iodized oil can be taken orally or by injection. It prevents hypothyroidism in the next generation when taken by women of child-bearing age

Figure 12 Plant for iodating salt by the spray-mixing process

The following precautions should be taken to preserve the iodine content of iodated salt:

Figure 13 Iodated salt should be packed in plastic-lined bags—*not* ordinary jute bags

Figure 14 Bags should be stored in dry, covered places—*not* in damp or poorly ventilated rooms, or in the open

Figure 15 Bags should be transported in closed vehicles—*not* in open trucks or wagons

Figure 16 Retailers should keep iodated salt indoors—*not* in the open. The salt should be kept in closed containers or plastic-lined bags—*not* in open boxes or ordinary jute bags

3. Estimation of Iodine Content in Iodated Salt

Principle

The iodine content in iodated salt is estimated by a process called iodometric titration. Free iodine reacts with sodium thiosulphate solution as follows:

$$\underset{\text{sodium thiosulphate}}{2Na_2S_2O_3} + \underset{\text{Iodine}}{I_2} = \underset{\text{sodium iodide}}{2NaI} + \underset{\text{sodium tetrathionate}}{Na_2S_4O_6}$$

Precautions

Adding sulphuric acid to a solution of iodated salt liberates iodine, which is titrated with sodium thiosulphate. Starch is used as an external indicator. Potassium iodide solution is added to keep the iodine in the dissolved state.

1. The starch solution must be added near the end of the titration, when very little iodine is left and the solution has a faint-yellow colour. If starch is added earlier, the iodine-starch complex becomes very strong and reacts too slowly with sodium thiosulphate, resulting in *false high* readings.
2. The titration should be done in a comfortably cool room because iodine is volatile and the sensitivity of the starch indicator diminishes as the temperature rises.
3. Potassium iodide (KI) is used because of the low solubility of iodine. The liberated iodine forms an unstable complex KI_3 with KI:

$$KI + I_2 = KI_3$$

$$I^- + I_2 = I_3^-$$

As free iodine is used up in the reaction with thiosulphate, the equilibrium between I_2 and I_3^- ions is disturbed and more iodine is dissolved in order to maintain the equilibrium.

4. A few minutes should be allowed before titration, since the rate of reaction between I^- ions and the oxidant is slow.
5. The reaction mixture should be kept in the dark before titration because light accelerates a side reaction in which iodide ions are oxidized to iodine by atmospheric oxygen.

4. Equipment and reagents

Equipment

1.	Laboratory balance for preparing reagents	1
2.	Gas burner or kerosene stove	1
3.	Small stainless steel bowl for boiling water to prepare starch solution	1 1
4.	Glass bottles with stoppers for reagents:	
	1,000 ml	1
	250 ml	3
5.	Small weighings scale with 10 gram weight	1
6.	Measuring cylinder with stopper, 50 ml	1
7.	Wash bottle, 500 ml	1
8.	Glass stirring rod	1
9.	Conical flask with stopper, 100 ml	1
10.	Glass or plastic funnel	1
11.	Pipette, 1 ml	1
12.	Pipette, 5 ml	1
13.	Burette, 10 ml and stand	1
14.	Clock or watch	1
15.	A closed box, cupboard or drawer to keep the conical flask	1

The approximate cost of the equipment is US $ 500 which would last for a minimum period of 10 years.

Reagents

1. Sodium thiosulphate – $Na_2S_2O_3$, Analytical Reagent Grade (AR)
2. Concentrated sulphuric acid – H_2SO_4, (AR)
3. Potassium iodide – KI, (AR)
4. Soluble chemical starch
5. Boiled double-distilled water, pharmaceutical grade

The approximate cost of reagents would be US $ 25 which would analyse 1000 salt samples.

5. Preparation of reagents

Sodium thiosulphate ($Na_2S_2O_3$)

Dissolve 1.24 grams $Na_2S_2O_3$ in 1 litre boiled double-distilled water. This volume is sufficient for testing 200 salt samples.

Store in a cool, dark place. Properly stored, the solution can be kept for a year.

2.N sulphuric acid (2H. H_2SO_4)

To 90 ml double-distilled water add 5.56 ml concentrated H_2SO_4 slowly. Add boiled, double-distilled water to make 100 ml. This volume is sufficient for testing 100 salt samples. Store in a cool dark place. The solution may be kept indefinitely.

CAUTION: To avoid violent and dangerous reaction always add the acid to water, *never* water to acid.

Potassium iodide (KI, AR)

Dissolve 10 grams KI in 100 ml double-distilled water. This volume is sufficient for testing 20 salt samples.

Store in a cool, dark place. Properly stored, the solution may be kept for 6 months.

Soluble Chemical Starch

Prepare 100 ml of saturated salt (NaCl) solution as follows. Dissolve sodium chloride (NaCl) reagent (AR) in 100 ml boiled, double-distilled water.

While stirring, add NaCl until no more dissolves. Heat the solution till NaCl crystals form on the sides of the vessel. Dissolve 1 gram of crystals in boiled, double-distilled water to make 100 ml.

Dissolve 1 gram chemical starch in 10 ml boiling double-distilled water.

Add the NaCl solution to make 100 ml starch solution.

This volume is sufficient for testing 20 salt samples. Prepare fresh starch solution every day, since starch solution cannot be stored.

6. Estimation of Iodine content in Iodated Salt

Laboratory procedure

Step 1 Carefully weigh 10 grams of the salt to be tested

Step 2 Pour the salt into a 50 ml measuring cylinder

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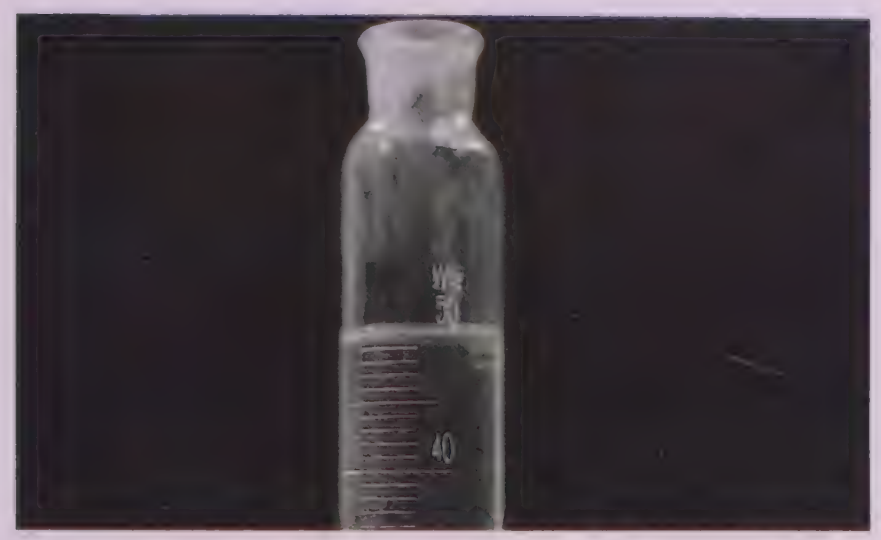
Step 3 Slowly add boiled, double-distilled water

Step 4 Shake to dissolve the salt completely

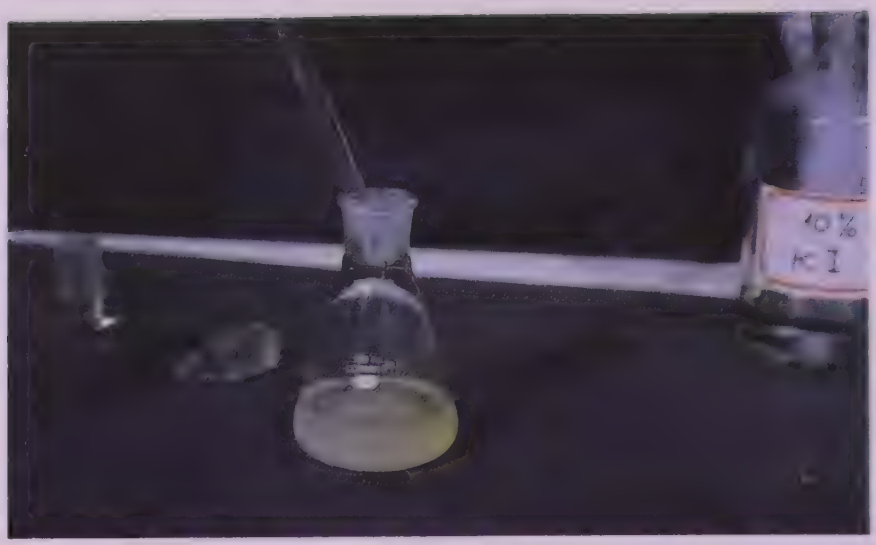
Step 5 Add more water



. . . to make 50 ml

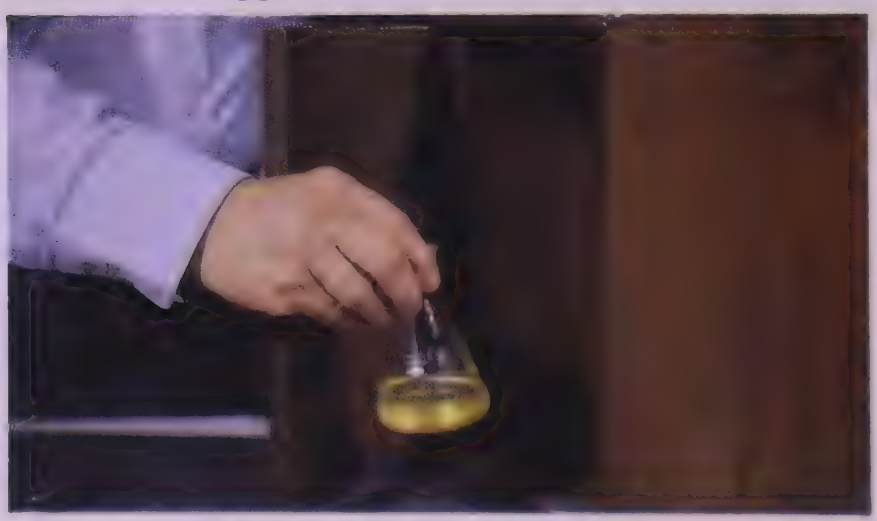
Step 6 Pour the salt solution (50 ml) into a conical flask with stopper

Step 7 Pipette out 1 ml of 2.N sulphuric acid. Add this to the salt solution

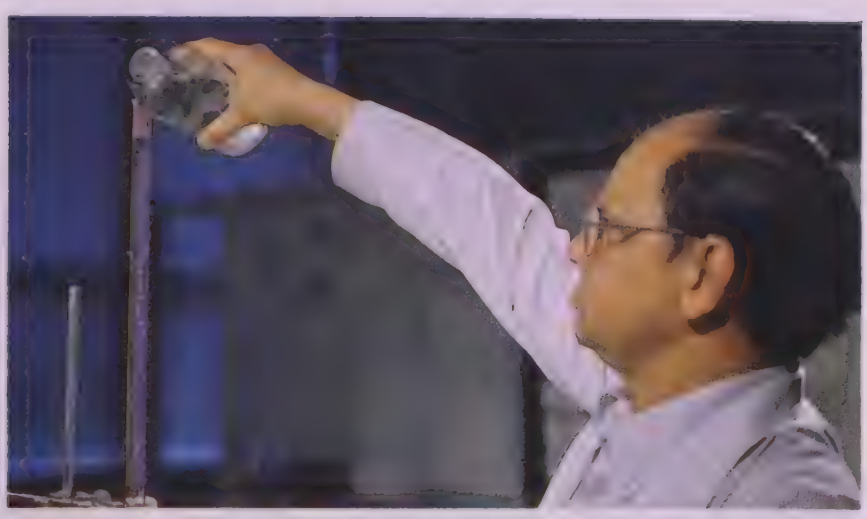


Step 8 Pipette out 5 ml of 10% potassium iodide and add to the salt solution

Step 9 The solution turns yellow. Close the flask with the stopper . . .



Step 10 . . . and put it in the dark for *10 minutes*. A closed box, cupboard or drawer may be used

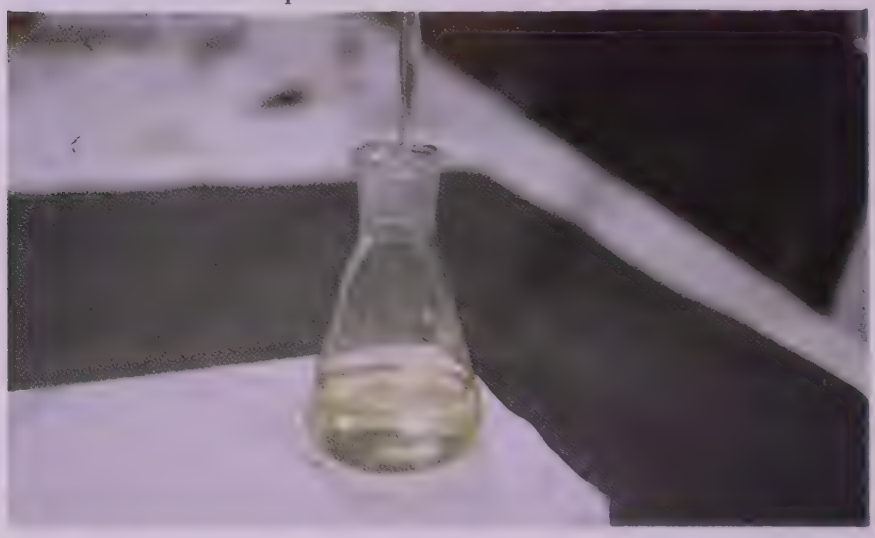


Step 11 Pour sodium thiosulphate into the burette

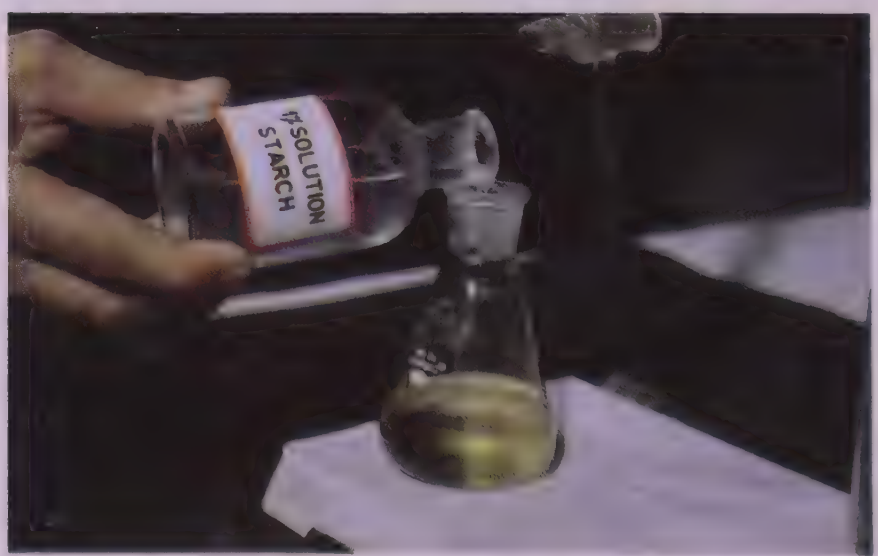
Step 12 Adjust the level to "0"

Step 13 *After 10 minutes*, take the flask out of the dark

Step 14 Shaking the flask, titrate with sodium thiosulphate



Step 15 Stop titration as soon as the solution turns *pale* (becomes very light yellow).

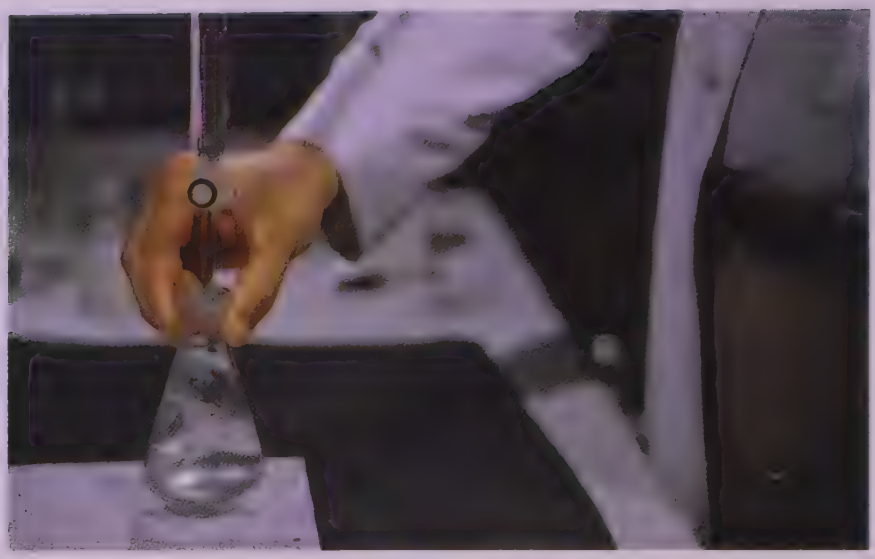


Step 16 Add a few drops (1 to 5 ml) of 1 % starch solution

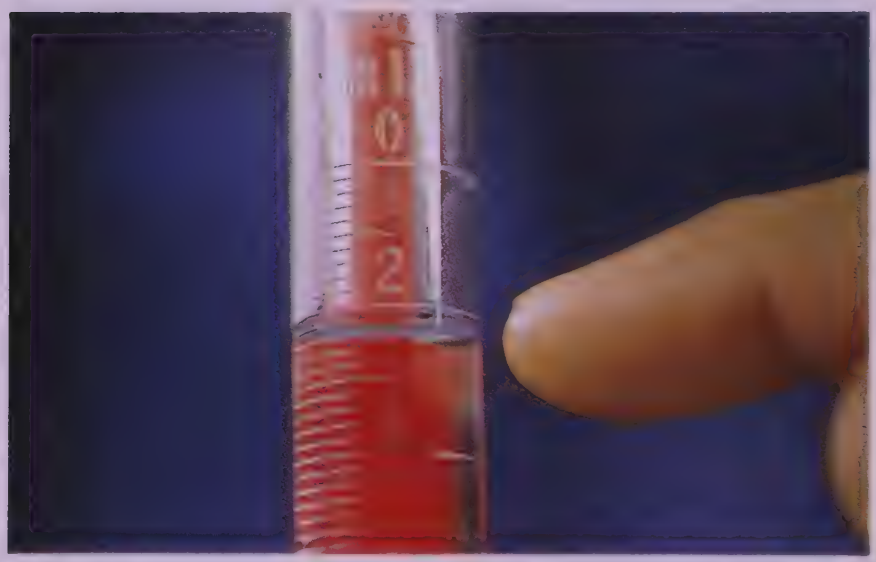
The solution turns deep purple

Step 17 Continue titration. . .

. . .until the purple coloration disappears. . .



. . .and the solution becomes colorless



Step 18 Note the burette reading

Step 19 From Chapter 7, read the iodine content of the sample in parts per million

Reporting

As you have seen, iodine testing is easy and takes only about twenty minutes per sample.

Maintaining *accurate* records is *as important as* the testing itself. Record your results in a register, indicating

- date of testing
- sample number
- salt manufacturer's name
- batch number of the salt
- date of iodation
- where the sample was taken from
- date of sampling and, finally,
- the level of iodine in the sample.

Make daily reports of your findings, and immediately alert your supervisor if you find less than the prescribed level of iodine. Your report will initiate a series of legal and other actions to protect the consumer. A delay on your part will delay these actions and harm the consumer.

7. Iodine content in parts per million

Burette reading	Parts per million	Burette reading	Parts per million
0.0	0.0	3.0	31.7
0.1	1.1	3.1	32.8
0.2	2.1	3.2	33.9
0.3	3.2	3.3	34.9
0.4	4.2	3.4	36.0
0.5	5.3	3.5	37.0
0.6	6.3	3.6	38.1
0.7	7.4	3.7	39.1
0.8	8.5	3.8	40.2
0.9	9.5	3.9	41.3
1.0	10.6	4.0	42.3
1.1	11.6	4.1	43.4
1.2	12.7	4.2	44.4
1.3	13.8	4.3	45.5
1.4	14.8	4.4	46.6
1.5	15.9	4.5	47.6
1.6	16.9	4.6	48.7
1.7	18.0	4.7	49.7
1.8	19.0	4.8	50.8
1.9	20.1	4.9	51.9
2.0	21.2	5.0	52.9
2.1	22.2	5.1	54.0
2.2	23.3	5.2	55.0
2.3	24.3	5.3	56.1
2.4	25.4	5.4	57.1
2.5	26.5	5.5	58.2

continued

Burette reading	Parts per million	Burette reading	Parts per million
2.6	27.5	5.6	59.2
2.7	28.6	5.7	60.3
2.8	29.6	5.8	61.4
2.9	30.7	5.9	62.4
6.0	63.5	8.0	84.6
6.1	64.5	8.1	85.7
6.2	65.6	8.2	86.8
6.3	66.7	8.3	87.8
6.4	67.7	8.4	88.9
6.5	68.8	8.5	89.9
6.6	69.8	8.6	91.0
6.7	70.9	8.7	92.0
6.8	71.9	8.8	93.1
6.9	73.0	8.9	94.2
7.0	74.1	9.0	95.2
7.1	75.1	9.1	96.3
7.2	76.2	9.2	97.3
7.3	77.2	9.3	98.4
7.4	78.3	9.4	99.5
7.5	79.4	9.5	100.5
7.6	80.4	9.6	101.6
7.7	81.5	9.7	102.6
7.8	82.5	9.8	103.7
7.9	83.6	9.9	104.7

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8. Glossary

Cretinism: A condition associated with iodine deficiency and goitre, commonly characterized by mental deficiency, deaf-mutism, squint, disorders of stance and gait, stunted growth, and hypothyroidism. "Chretien", old French for Christian. The Arian refugees settled in the Pyrenees (the mountain range stretching from the Mediterranean Sea to the Atlantic Ocean, separating France and Spain) and because of persecution, retired into remote valleys. As a result of restricted diet, isolation, intermarriage, etc., as well as low iodine content in their food, children often had peculiar stunted bodies and backward minds, a condition later known to be associated with thyroid deficiency. The term "chretien" for this kind of Christian seems to have developed as a term of contempt and was applied to other children of the same kind in other localities. Paracelsus (a Swiss physician, 1493–1541) was the first to point out the relation between goitrous parents and children who were cretins. The word appeared in English in 1779.

Deaf-mutism : State of being both deaf and dumb.

Endocrine gland : A gland which releases its secretions directly into the blood-stream.

First in, first out : Bags of iodated salt which are brought into storage first, should be the ones to be removed first. The objective is to reduce storage time to the minimum.

Foetus : Also "fetus". Latin for offspring, that which is brought forth; from "feo", I bring forth. The term is now restricted to the unborn offspring, the child in the womb. Until the third month of pregnancy, the developing child is called an "embryo", after that, a "foetus".

Gait : Manner of walking.

Goitre : Enlargement of the thyroid gland. In Latin, "guttur", the throat. The condition was known to the ancients; the Romans called it "bronchocele". The term goitre is, however, of comparatively recent origin.

Hormone : Specialised chemical secretions of endocrine glands, which are released directly into the blood, and exert specific effects on their target organs.

Hypothyroidism : Condition characterized by an insufficiency of thyroxine, a hormone synthesised from iodine by the thyroid gland. "Hypo"—in Greek, deficient, below, under.

Incidence (of NH) : Number of people getting the disease as a proportion of the population at risk during a given period of time. Incidence tells us the rate at which new illness occurs.

Iodation (of salt) : Fortification of common salt with potassium iodate.

Iodine : A non-metallic element belonging to the halogen group. It is a black crystalline substance having a density of about five. It melts a 114 degrees Centigrade and boils at a slightly higher temperature, giving off a characteristic violet vapour. Its atomic number is 53, and atomic weight is 126.92.

Iodine was first isolated in 1812 by Bernard Courtois, a French manufacturing chemist. He noticed that the use of kelp (seaweed) was associated with the corrosion of copper pots used to manufacture saltpetre. He extracted the kelp to see what was in it, and discovered a new substance. 'The wonderful colour of its vapour suffices to distinguish it from all other substances known upto the present time, and it has further remarkable qualities which render its discovery of the very greatest interest'. "Iodine" is Greek for violet.

Sir Humphrey Davy (English chemist, 1778-1829) who was visiting Paris at that time obtained a small amount of the new substance and hurried home to investigate it. He then published several papers about it and named it iodine 'as this name would be more analogous to chlorine and fluorine', both of which he had discovered.

The use of iodine in medicine was slow to develop—Coindet in 1820 noted that cases of goitre improved with it, but this was an isolated observation. Although the connection between iodine and the thyroid gland had been observed empirically, it was not fully understood until 1889 when the French pathologist Gley demonstrated the presence of iodine in the gland. In 1912, E.C.Kendall of the Mayo Clinic, USA, studying the thyroid, isolated an iodine-bearing substance which he called "thyroxine". Later, the chemical nature of thyroxine was determined by Harington of the University of London in 1926.

Iodine deficiency disorders (IDD) : The effects of iodine deficiency can show up during every stage of life. Goitre is one of the better-known manifestations of iodine deficiency. The term "Iodine Deficiency Disorders" describes the whole spectrum of ill-effects which include stillbriths, abortions, congenital abnormalities, cretinism, and impaired mental function associated with hypothyroidism.

Iodized oil : Is an organic compound of iodized ethyl esters of fatty acids of poppy seed oil. In China soya bean and walnut oil have been used to make iodized oil compounds. Only oils containing unsaturated fatty acids can be iodized.

Commercially available iodized oil, which is manufactured in France, contains 480 milligrams of iodine per millilitre (38% iodine by weight). This oil can be injected or given orally to prevent IDD.

Iodization (of salt) : Fortification of salt with potassium iodide, a compound of iodine.

Neonatal : Concerning the newborn. The neonatal period refers to the first 30 days of an infant's life. "Neo", Greek for new or recent. "Natare", Latin, to be born.

Neonatal hypothyroidism (NH) : Condition in the newborn with thyroid hormone deficiency.

Nutrient : Substance that supplies the body with the elements necessary for normal functioning.

Perinatal (mortality rate) : Number of foetal deaths after the 28 th week of pregnancy, plus the number of deaths of infants under seven days of age, per 1000 live briths. "Peri", Greek, prefix meaning around or about. "Natal", Latin, pertaining to brith or the day of brith.

Potassium iodate (KIO_3) : A relatively stable compound of iodine, containing 59.5 % iodine. It can be tolerated by the human body in large amounts to provide iodine to the thyroid gland to synthesise thyroxine.

Prevalance (rate) : Number of persons with the same disease at the same time per population at risk.

Squint : Inability of the eyes to look in the same direction together.

Stance : Position of body when standing.

Still brith : Birth of a dead foetus.

Stunting : Shortness due to retarded growth.

Tarai : Foothills and adjacent plains of the sub-Himalayan region.

Thyroid : An endocrine gland, which secretes a hormone thyroxine. It is located at the base of neck and extends on both sides of the midline.

"Thyroid", in Greek, is a large oblong shield. The word was used in Homer's *Odyssey*, the Greek epic. Later, the same word was applied to a long shield carried by soldiers which covered them from neck to ankle, with a deep notch at the top for the chin. It was this shield that suggested the name "thyroid" for the cartilage in the neck. The name "thyroid gland" was coined in 1646 by Thomas Wharton, an English physician and anatomist.

Thyroxine : A hormone which contains iodine and is synthesised and secreted by thyroid gland. Thyroxine plays a vital role in the normal growth and development of the human brain, early in life and metabolic processes.

Titration : Volumetric analysis to determine the concentration of a solution by gradually adding another solution of known concentration.

Umbilical cord : Tube connecting the foetus to the placenta. The foetus derives its nourishment through this tube. The umbilical cord is cut when the child is born.

ADDENDUM

Page-Zero : in "Consultants", please add 'Mrs Nilima Chawla'.

Page-2 : Figure 1 - please add after "Hypothyroidism", 'immediately after childbirth'.

Page-12 : Line 31, please read 'sale of uniodated or substandard iodated salt ……,' (instead of salt of uniodated ……).

Page-20 (para 1) : *Sodium Thiosulphate ($Na_2S_2O_3$)*
Please read 'the solution can be kept for few months' (instead of, 'the solution can be kept for a year').

Soluble Chemical Starch:

Soluble chemical starch is prepared by disolving it in saturated sodium chloride (NaCl) solution:

Take 100 ml. double distilled water in a beaker and go on adding crystalline NaCl to the water. Keep on stirring continously. Continue to add crystalline NaCl till no more salt in soluble. Then heat the contents of the beaker till excess salt dissolves, while cooling, the NaCl crystals will appear on the sides of beaker. When it is completely cooled, decant the supernant in a clean bottle. This can be stored for 3 to 4 weeks.

Preparation of Soluble Chemical Starch:

Add 1 gm of chemical starch in 10 ml. of boiling double distilled water. Continue to boil till it completely disolves. Add saturated NaCl solution to make 100 ml. The 100 ml. solution of soluble chemical starch is sufficient for testing 20 salt samples. Since starch solution can not be stored, therefore, everyday fresh starch solution has to be prepared.

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